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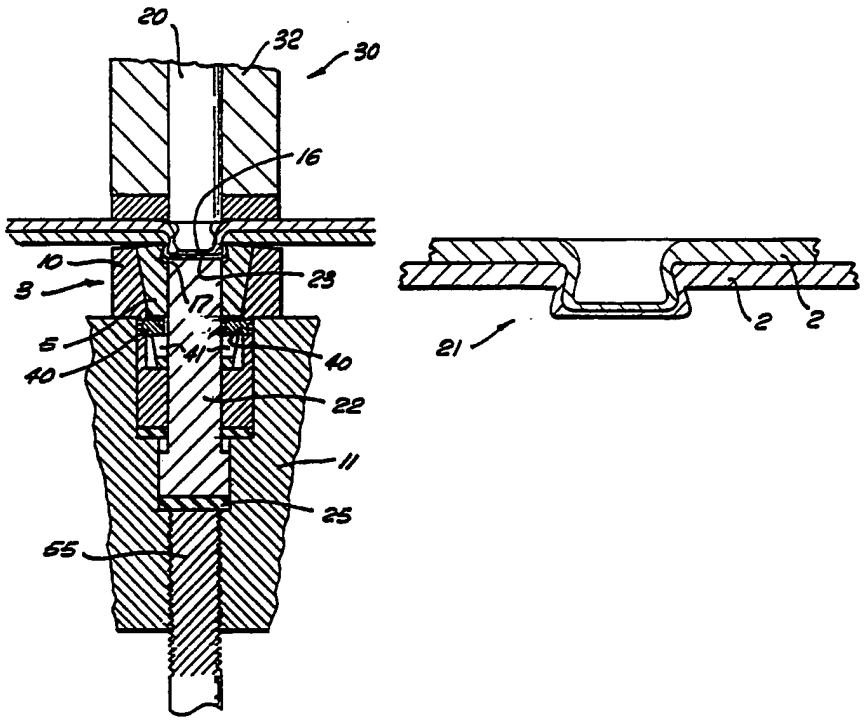
(54) Title: CLINCHING TOOL FOR SHEET METAL JOINING

(57) Abstract

A clinching apparatus (1) for joining overlapping portions of sheet material (2). The apparatus includes a die (3) comprising a plurality of discrete forming elements (5). Guide means are provided to force the forming elements (5) into close abutment in a closed configuration in response to movement thereof in a first direction to define a void (16) bounded by an effectively continuous peripheral surface (17), and to permit the forming elements (5) to move apart into an open configuration in response to movement thereof in second opposite direction. The apparatus further includes a punch (20) operable in conjunction with the die (3) to force the sheet material (2) into the void (16) to form a clinch (21) fastening the overlapping portions together. The clinch (21) is releasable from the die (3) by movement of the forming elements (5) in the second direction toward the open configuration.



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Title: CLINCHING TOOL FOR SHEET METAL JOINING

FIELD OF THE INVENTION

The present invention relates to fastening tools and in particular to a clinching apparatus for joining overlapping portions of sheet material without the need for independent fastening elements such as rivets or nails.

The invention has been developed primarily for use with sheet metal and will be described hereinafter with reference to this application. However, it will be appreciated that the invention is not limited to this particular field of use.

BACKGROUND OF THE INVENTION

Various clinching tools are known and usually comprise a punch operable in conjunction with a complementary die to plasticly deform the overlapping

portions of metal and form a clinch which fastens the sheets together.

One such device includes a multi-segmented die bounded by a flexible restraining band permitting the die to resiliently open during the clinching operation. In the open configuration, however, particulate debris is permitted to migrate into the clearances between adjacent die segments. Repeated use causes the die to become clogged which prevents efficient operation of the tool.

Known clinching tools also suffer from an additional problem in that the wall thickness of the sheet material in the vicinity of the neck of the clinch tends to be significantly reduced because of the way in which the metal is extruded into the die. In some cases, the wall thickness in the region of the clinch can be reduced by in excess of 80% of the nominal gauge thickness of the metal, which significantly reduces the maximum shear strength of the clinch. In addition, the joint so formed is highly stressed in the vicinity of the clinch and therefore more susceptible to corrosion which directly affects the longevity of the joint. In many applications, for example in the building industry, these problems have prevented the widespread commercial acceptance of clinching as a viable means of assembly and construction in sheet metal because of the resultant difficulty encountered in meeting stringent safety

requirements.

In addition to the problems of reduced wall thickness, inadequate shear strength, and reduced corrosion tolerance, the side walls of the die in so called "fixed die" tools must either be parallel or diverge outwardly in order to permit release of the clinch from the die. This inherent restriction in fixed die devices limits the maximum degree of interlocking mechanical engagement between the metal sheets forming the clinch and consequently limits the maximum "pull-out" strength of the joint.

It is therefore an object of the present invention to provide an improved clinching tool which overcomes or substantially ameliorates at least some of these disadvantages of the prior art.

DISCLOSURE OF THE INVENTION

Accordingly, in a first aspect, the invention provides a clinching apparatus for joining overlapping portions of sheet material, said apparatus including a die comprising a plurality of discrete forming elements, guide means to force said forming elements into close abutment in a closed configuration in response to movement thereof in a first direction to define a void bounded by an effectively continuous peripheral surface and to permit said forming elements to move apart into an open configuration in response to movement thereof in a second opposite direction, and a punch operable in

conjunction with said die to force said sheet material into said void to form a clinch fastening said overlapping portions together, said clinch being released from said die by movement of said forming elements in said second direction toward said open configuration.

Preferably, the die comprises at least two complementary collets and the guide means includes a guide block disposed within a body and defining an outwardly diverging generally frusto-conical socket. The collets together preferably define a complementary frusto-conical outer surface slidingly engageable with the conical socket of the guide block such that movement of the collets into the socket in the first direction causes the collets to be forced tightly together into the closed configuration. Conversely, movement of the collets out of the socket in the second opposite direction permits the collets to move apart into the open configuration to release the clinch from the die.

The apparatus preferably also includes a centrally disposed floating die member mounted for limited independent axial sliding movement within the body and between the collets to define a lower boundary of the void. The degree of axial sliding movement is preferably controlled by resilient compression means to provide a passive restoring force tending to urge the floating die toward the void once the clinch has been

formed.

The resilient compression means preferably comprises a first deformable element of predetermined resiliency disposed effectively intermediate the body and the floating die. In one preferred embodiment, a second resilient compression element is disposed effectively intermediate the guide block and the floating die to provide a degree of independent relative movement between the die, the guide block, the floating die member and the body, thereby to accommodate surface irregularities in the sheet material and provide a degree of gauge tolerance. The resilient compression means may comprise a compressible packing element formed from a suitable material such as lurethane, a compressible fluid, or a spring, for example.

In another embodiment, the resilient compression means may be supplemented or replaced by positive drive means such as an hydraulic cylinder acting in conjunction with a tapered wedge member, whereby the floating die is actively driven toward the void during the latter part of the clinching cycle thereby to "flare" the clinch and enhance mechanical interengagement of the overlapping sheets.

The apparatus preferably also includes independently operable clamping means to clamp the sheet material intermediate the punch and the die. The clamping means preferably includes a press having a

clamping member defining a generally annular clamping surface coaxial with the punch and cooperable with a corresponding opposed upper surface of the die. In this preferred embodiment, selective actuation of the clamping press forces the clamping member toward the die, thereby clamping the sheet material between the annular clamping surface and the corresponding upper surface of the die. This action simultaneously drives the collets into the complementary frusto-conical socket formed in the guide block to close the die prior to independent actuation of the punch to form the clinch. In the preferred embodiment, the clamping member is formed with an outwardly protruding convex clamping surface configured to force the sheet material into the void during the clinching cycle. Preferably, the clamping surface is partially spherical and incorporates an outwardly protruding annular shoulder surrounding the punch.

The apparatus preferably also includes restraining means to limit the maximum axial excursion of the collets in the second direction relative to the guide block. The restraining means in one embodiment comprises a plurality of locating lugs extending inwardly from the guide block into the conical socket and engaging corresponding oversized apertures formed in the respective collets to provide a limited degree of free play in the first and second directions

corresponding to the radial clearance defined between the locating lugs and the respective apertures. In another embodiment, the retaining means comprises a circlip surrounding the remote end of the die, such that the maximum axial excursion of the die in the second direction corresponds to a point at which the circlip abuts a lower surface of the guide block, which is conveniently retained with the body within an interference fit.

In another preferred form of the invention, the collets define a plurality of lobes or protuberances in the void such that the resultant clinch prevents relative rotation of the constituent portions of sheet material. To this end, it will be apparent that a range of non-circular die shapes such as polygonal or elliptical can be used to produce non-rotational joints.

According to a second aspect, the invention provides an independent multi-cylinder actuating device for a clinching apparatus substantially as described above, said actuating device including a first force exerting member reciprocably moveable by a first fluid cylinder, and a second force exerting member reciprocably moveable independently of the first member by a second fluid cylinder, an outer surface of the first member forming an inner surface of the second cylinder such that an operating volume of the second cylinder is defined partly by the first member.

In the preferred embodiment, the actuating device acts in cooperation with the clinching apparatus whereby the first member actuates the punch and the second member independently actuates the clamping press. The first and second cylinders are preferably hydraulic. However, it will be appreciated that pneumatic cylinders, for example, can also be used.

According to a third aspect, the invention provides a clinching assembly comprising a clinching apparatus substantially as described, and an actuating device substantially as described, wherein the first force exerting member actuates the punch and the second force exerting member independently actuates the die.

The actuating device and clinching apparatus are preferably maintained in relative coaxial alignment by a generally C-shaped support frame. In an alternative configuration, however, a pair of clinching apparatus may be supported in spaced apart relationship by a generally E-shaped support frame to enable parallel flanges of a beam to be clinched simultaneously.

BRIEF DESCRIPTION OF THE DRAWINGS

Preferred embodiments of the invention will now be described, by way of example only, with reference to the accompanying drawings in which:

Figure 1 is a cut-away sectional view of a clinching apparatus according to a first embodiment of the invention with the die in the open configuration;

Figure 2 shows the clinching apparatus of figure 1 in operation with the die in the closed configuration;

Figure 3 is a sectional view showing a clinch formed with the tool of figures 1 and 2;

Figure 4 shows a second embodiment of the clinching apparatus according to the invention;

Figure 5 is a cross-sectional view showing an alternative embodiment of the clamping member of figures 1 and 2, incorporating a convex clamping surface and outwardly protruding annular shoulder;

Figure 6 is a perspective view showing an alternative embodiment of the die, incorporating a plurality of lobes to form non-rotational joints;

Figure 7 shows another embodiment of the clinching apparatus wherein the die is retained for limited axial excursion within the guide block by a circlip;

Figure 8 is an exploded view of the punch and die assembly of the embodiment of figure 7;

Figure 9 is a diagrammatic cross-sectional view showing a further embodiment wherein the resilient compression means incorporates a compression spring and wedge assembly operable on the floating die;

Figure 10 is a cross sectional view similar to figure 9 but incorporating active hydraulic-mechanical drive means;

Figure 11 shows an alternative embodiment of the active hydraulic-mechanical drive means of figure 10;

Figure 12 is a cut-away sectional view showing a multi-cylinder actuating device according to a second aspect of the invention;

Figure 13 is a sectional side elevation showing a clinching assembly according to a third aspect of the invention.

PREFERRED EMBODIMENT OF THE INVENTION

Referring generally to the drawings, wherein corresponding features are denoted by corresponding reference numerals, a clinching apparatus 1 for joining overlapping portions of sheet material 2 includes a die 3 comprising a plurality of discrete mutually opposed forming elements in the form of complementary collets 5. The apparatus further includes guide means in the form of guide block 10 disposed within body 11 and defining an outwardly diverging frusto-conical socket 12. The collets 5 together define a complementary frusto-conical outer surface 15 nestably engageable with conical socket 12 of the guide block 10. In this way, movement of the die into the socket forces the collets into close abutment in a closed configuration (as shown in figure 2) to define a void 16 bounded by an effectively continuous peripheral surface 17. Conversely, movement of the die outwardly from the socket 12 away from the guide block permits the collets to move apart into an open configuration as shown in figure 1. The sides of the socket 12 are preferably

inclined at an angle of around 10° to the vertical. However, this angle can be varied to suit particular applications and material types and thicknesses. For example, with higher loads it is envisaged that an angle of around 15° would be used.

A selectively operable punch 20 having a domed head acts in conjunction with die 3 to force the sheet metal 2 into the void 16 to form a clinch 21 securely fastening the overlapping sheets together. The clinch 21 is released from the die by movement of the collets outwardly from the guide block toward the open configuration.

A floating die member 22 coaxial with punch 20 is mounted for limited independent axial sliding movement within body 11 and between collets 5 to define a lower boundary 23 of the void 16. In the embodiments of figures 1 and 4, the degree of axial sliding movement is passively controlled by a first deformable compression element 25 of controlled resiliency disposed intermediate the body 11 and the floating die 22. The resilient compression element 25 preferably has a definite end point beyond which substantially no further compressive deformation is possible, and provides a restoring force tending to urge the floating die upwardly toward the void. Similarly, a second resilient annular compression element 26 is disposed effectively between the guide block 10 and a stepped shoulder of the

body 11. Resilient compression elements 25 and 26 together provide a limited degree of independent relative movement between die 3, guide block 10, floating die 22, and body 11, thereby to accommodate surface irregularities in the sheet material and provide a degree of gauge tolerance for the tool. As shown in figure 4, an additional compression element 27 may also be interposed effectively between the floating die and the guide block if required.

The resilient elements are preferably formed from a suitable material such as Lurethane which can be appropriately trimmed or "tuned" to provide the required degree of resilient deformation. However, it will be appreciated that various configurations of packing elements or other means such as an adjustably damped viscous hydraulic circuit, or a compressible fluid, could also be used. For example, in the embodiment of figure 9, the floating die is urged upwardly toward the void by a spring biased conical wedge member acting against complementary split collets abutting the lower surface of the floating die, as described in more detail below.

The resilient compression means may also be supplemented or replaced by positive drive means such as an hydraulic cylinder acting in conjunction with a tapered wedge member as will be described below in relation to figure 10 whereby the floating die may be

actively driven upwardly into the void during the latter part of the clinching cycle to increase the "mushrooming" effect by flaring the neck of the clinch as the sheet material is driven into the void by the punch. The positive drive means also assists in automatically releasing the clinch from the die.

The apparatus further includes independently operable clamping means 30 to firmly clamp the sheet material between the punch and the die during the clinching operation. The clamping means includes a press having reciprocable clamping member 32 defining a generally annular clamping surface 33 coaxial with the punch 20 and cooperable with a corresponding opposed upper surface 35 of the die 3. Selective actuation of the clamping press forces clamping member 32 downwardly toward die thereby securely clamping the sheet material between annular clamping surface 33 and the corresponding upper surface 35 of the die. This clamping action simultaneously drives the collets downwardly into the socket 12 formed in the guide block to tightly close the die prior to independent actuation of the punch to form the clinch.

As shown in figure 5, the clamping member is preferably formed with an outwardly protruding convex clamping surface incorporating a protruding annular shoulder 37 to urge material into the void during the clamping operation and thereby enhance the strength of

the resultant clinch.

The die also includes restraining means to limit the maximum axial excursion of the collets with respect to the guide block. The restraining means in the embodiments of figures 1 and 4 comprises a pair of mutually opposed locating lugs 40 extending radially inwardly from the guide block into the conical socket 12 and engaging corresponding over-sized apertures 41 formed in the respective collets. This provides a limited degree of free play between the collets and the guide block, corresponding to the radial clearance defined between locating lugs 40 and respective apertures 41. The extreme positions of the collets relative to the guide block correspond respectively to the open and closed configurations of the die.

In the embodiments shown in figures 7 to 11, however, the retaining means comprises a circlip 42 extending around a lower cylindrical neck portion 43 of the die. In these embodiments, the maximum axial excursion of the die in the second direction corresponds to the point at which the circlip abuts the lower surface of the guide block, which is retained within the body with an interference fit. The circlip also serves to keep the die together and operating efficiently, particularly in embodiments where the die comprises three or more forming elements or collets, such as that as shown in figure 6.

The clinching apparatus is preferably operated by an independent multi-cylinder actuating device 45 including a first piston 46 reciprocably moveable by a first hydraulic cylinder 47 and a second piston 48 reciprocably moveable independently of the first piston 46 by a second hydraulic cylinder 49. The outer surface 50 of the first piston 46 forms a common inner surface of the second cylinder 49 such that the toroidal operating volume 51 of the second cylinder 49 is defined partly by the first piston. The actuating device 45 acts in cooperation with the clinching apparatus whereby the first piston 46 operates the punch 20 and the second piston 48 independently operates the clamping member 32. Advantageously, the independence of the punch cylinder 47 in relation to the clamping cylinder 49 permits a varying depth of clinch in the overlapping sheets related to sheet thickness and material type, which again increases the guage tolerance of the tool. The actuating device and clinching tool are held in relative coaxial alignment by a generally C-shaped steel support frame 52 as shown in figure 10, whereby the integrated clinching assembly can be conveniently transported and used by a single operator.

Turning now to describe the operation of the apparatus, the overlapping portions of sheet material are first inserted between the punch and the die as best seen in figure 1. The clamping press is then actuated

to clamp the sheet material between clamping surface 33 of the press and complementary surface 35 of the die, and simultaneously wedge the collets tightly into the guide block to close the die. The clamping action also forces the overlapping sheets together into close abutment prior to actuation of the punch to ensure that an effective clinch is formed even in the event of local irregularities or surface defects in the sheet metal.

With the sheet material clamped firmly in place and the die tightly closed, the punch is then actuated by the first piston 46 under the action of hydraulic cylinder 47 to force the sheet material downwardly into void 16 and outwardly into forming engagement with peripheral surface 17 of the die thereby to form the clinch 21. It will be appreciated that the outwardly converging tapered configuration of the peripheral surface 17 of the die increases the mechanical interlocking engagement between the overlapping sheets of metal to maximise the pull-out strength of the joint. The internal void angle α (figure 8) defined by peripheral surface 17 is preferably in the range of around 5° to 50° to maximise the "mushrooming" effect, particularly in softer materials. A three or four element die such as that shown in figure 6 is preferred in applications requiring higher internal void angles to facilitate release once the clinch has been formed. Additionally, the clamping press prevents undesirable

local distortion of the metal immediately adjacent the joint during the formation of the clinch and thereby further contributes to the resultant strength of the joint.

In the embodiment of figures 1 and 4, the forming action of the punch simultaneously drives floating die 22 downwardly by a predetermined incremental amount corresponding to the degree of resilient deformation provided by controlled compression element 25. Similarly, the guide block is provided with a limited degree of relative movement with respect to the body by means of the second resilient compression elements 26 or 27 to accommodate slight variations in gauge thickness and compliance of the sheet metal.

Once the clinch has been formed, the punch 20 is withdrawn whereupon the resilient compression element 25 provides a restoring force tending to urge the floating die 22 upwardly toward the void and into abutting engagement with the lower face of the clinch. This action tends to flatten the clinch and simultaneously flare the neck outwardly to further increase the degree of interlocking engagement between the overlapping sheets. The clamping press is subsequently withdrawn whereby the unrestrained restoring force provided by the resilient compression elements tends to urge the collets upwardly, away from the guide block and into the open configuration to automatically release the clinch from

the die. The maximum upward excursion of the collets is limited by retaining lugs 40 acting in conjunction with respective apertures 41 which together define the open configuration for the die.

It will be appreciated that this arrangement provides the dual advantages of increased interlocking engagement provided by the tapered configuration of the void lacking in known fixed die devices, together with a simple automatic release mechanism to increase the throughput in high rate production applications. This obviates the need for an independent releasing step which in some prior art devices can require a stripping force of the same order of magnitude as the shear strength of the joint.

The position of the floating die, the guide block, and the collets can be conveniently adjusted relative to the body by means of threaded adjustment plug 55 to accommodate sheet metal of varying thickness. In addition, the end point of the compression provided by the resilient packing elements can be conveniently adjusted by the incorporation of tuning slots or varying the available volume into which the resilient elements can expand.

In the embodiment of figure 9, the floating die is urged upwardly toward the void by a transverse spring biased conical wedge member 62 engaging complementary split collets 63 which abuttingly engage a lower surface

64 of the floating die. Compression spring 65 resiliently deforms to accommodate a degree of axial displacement of the floating die during the clinching cycle, and subsequently applies a corresponding restoring force to flare the clinch within the void. The position of the conical wedge member can be conveniently tuned using adjustment nuts 66.

As shown in figures 10 and 11, the passive resilient compression elements may be supplemented or replaced by positive drive means 70 such as an hydraulic cylinder 71 operable in conjunction with the tapered conical wedge member 62 and a suitable control system (not shown) whereby the floating die is actively driven upwardly into the void at the appropriate stage during the clinching cycle. As with the embodiments of figures 1, 4 and 9, this action tends to flatten the clinch and simultaneously flare the neck outwardly into the void to further increase the degree of interlocking engagement between overlapping sheets. It can also serve as an automatic release mechanism.

In figure 11, the conical wedge member 62 and split collets 63 are disposed symmetrically within the body so that the apparatus can be readily adapted to simultaneously operate a second opposed die assembly (not shown) for simultaneously clinching spaced apart beam flanges, for example. Again in this embodiment, the position and limits of excursion can be adjusted by

nuts 66.

As shown in figure 6, the collets may be configured to define a plurality of lobes 80 in the die which effectively prevent relative rotation of the sheet material around the clinch. It will be appreciated, however, that any suitable non-circular die shapes, for example polygonal or elliptical, can be used to achieve this result.

The unique configuration of the collets, guide block, floating die and body are such that the wall thickness in the vicinity of neck of the clinch can approach 90% or more of the nominal gauge thickness of the sheet metal. This significantly increases the shear strength of the clinch relative to known devices and also provides a corresponding increase in corrosion tolerance. It has been found that the shear strength of a clinch formed by the invention can approach the maximum material strength of the constituent metal which represents a significant improvement over the prior art.

In this regard, Table "A" below shows preliminary test data for a clinching tool embodying the present invention and results obtained from a comparable prior art device. Controlled tests were conducted on samples prepared from elongate flat strips of sheet steel effectively 0.750 inches wide in a variety of thicknesses and joint configurations as outlined in the table. Overlapping strips were clinched to form samples

of 100 mm effective overall length which were then tested to destruction in a tensile testing machine to determine the effective shear strengths of the joints.

TABLE A

TEST BATCH NUMBER	SHEET MATERIAL THICKNESSES (mm)	AVERAGE MAXIMUM SHEAR STRENGTH OF CLINCHED JOINT (N)	
		CLINCHING TOOL ACCORDING TO THE PRESENT INVENTION	COMPARABLE PRIOR PRIOR ART DEVICE
1	1.2/1.2	6380	1800
2	1.6/1.6	6050	3250
3	1.6/1.2	>7480*	3200
4	1.2/1.2 (longitudinally aligned double clinch)	>7150*	N/A
5	1.0/1.0/1.0 (3 overlapping sheets - single clinch)	6825	N/A
		Ultimate tensile strength of comparable test sample formed from sheet material of 1.2mm thickness = 7850N	

* Shear strength of joint exceeded ultimate tensile strength of material in at least one case.

It will be seen from the above that the strength of the clinched joint closely approaches the maximum strength of the sheet material. Indeed in some cases, the test samples failed in tension away from the joint

leaving the clinch intact, indicating a joint shear strength exceeding the ultimate tensile strength of the constituent sheet material.

These advantages make the clinching apparatus particularly suitable for use in the fabrication of structures from sheet metal, since the substantial increase in strength of the joints enables stringent safety requirements to be met comfortably without the need for supplementary fastening means such as welding, bolts, rivets, or screws. The invention has particular advantage in its application to the housing, construction and building service industries in which steel frame fabrication is beginning to take a prominent place over more conventional construction techniques.

Although the invention has been described with reference to specific examples, it will be appreciated by those skilled in the art that the invention may be embodied in many other forms.

CLAIMS:-

1. A clinching apparatus for joining overlapping portions of sheet material, said apparatus including a die comprising a plurality of discrete forming elements, guide means to force said forming elements into close abutment in a closed configuration in response to movement thereof in a first direction to define a void bounded by an effectively continuous peripheral surface and to permit said forming elements to move apart into an open configuration in response to movement thereof in second opposite direction, a punch operable in conjunction with said die to force said sheet material into said void to form a clinch fastening said overlapping portions together, said clinch being releasable from the die by movement of the forming elements in the second direction toward the open configuration.

2. A clinching apparatus according to claim 1 wherein said guide means includes a guide block disposed within a body and defining an outwardly diverging generally frusto-conical socket.

3. A clinching apparatus according to claim 2 wherein said forming elements comprise at least two complementary collets together defining a generally frusto-conical outer surface slidably engageable with the socket of the guide block such that movement of the collets into the socket in the first direction causes

the collets to be forced tightly together into the closed configuration, and movement of the collets outwardly from the socket in the second opposite direction permits the collects to move apart toward the open configuration to release the clinch from the die.

4. A clinching apparatus according to claim 2 or claim 3 wherein a side of the conical socket is inclined at an angle of between approximately 5° and 30° to the vertical.

5. A clinching apparatus according to claim 4 wherein the side of the conical socket is inclined at an angle of between approximately 8° and 15° to the vertical.

6. A clinching apparatus according to any one of the preceding claims wherein the peripheral surface of the void defines an internal angle of between approximately 5° and 50° to the vertical.

7. A clinching apparatus according to any one of the proceeding claims wherein said punch is formed with a domed head.

8. A clinching apparatus according to any one of claims 2 to 7, further including a centrally disposed floating die member mounted for limited axial sliding movement between the forming elements to define a lower boundary of the void.

9. A clinching apparatus according to claim 8 wherein the degree of axial sliding movement of the floating die is partly controlled by resilient compression means

providing a passive restoring force to urge the floating die toward the void.

10. A clinching apparatus according to claim 9 wherein the resilient compression means has a definite end point beyond which substantially no further compressive deformation is possible.

11. A clinching apparatus according to claim 9 or claim 10 wherein the resilient compression means comprises a first resilient compression element of predetermined resiliency disposed effectively intermediate the body and the floating die member.

12. A clinching apparatus according to claim 11, further including a second resilient compression element disposed effectively between the guide block and the floating die member to permit a degree of independent relative movement between the die, the guide block, the floating die member, and the body, thereby to accommodate surface irregularities in the sheet material and provide a degree of gauge tolerance.

13. A clinching apparatus according to any one of claims 9 to 12 wherein the resilient compression means is formed from lurethane.

14. A clinching apparatus according to any one of claims 9 to 12 wherein the resilient compression means includes a compressible fluid.

15. A clinching apparatus according to any one of claims 1 to 8 further including positive drive means

whereby the floating die member is actively driven toward the void during a clinching cycle to flatten and flair the clinch and thereby increase the degree of mechanical interlocking engagement between the overlapping portions of sheet material.

16. A clinching apparatus according to claim 15 wherein said drive means includes an hydraulic or pneumatic actuator cooperable with a tapered wedge member, whereby the floating die is urged toward the void.

17. A clinching apparatus according to claim 15 or 16, further including control means adapted to actuate said drive means at a predetermined point during the clinching cycle.

18. A clinching apparatus according to any one of claims 1 to 17, further including restraining means to limit the maximum axial excursion of the forming elements in the second direction relative to the guide block.

19. A clinching apparatus according to claim 18 wherein said restraining means comprises a plurality of locating lugs extending inwardly from the guide block into the conical socket and respectively engaging a corresponding plurality of oversized apertures in the respective forming elements to provide a limited degree of free play in the first and second directions corresponding to the radial clearance defined between the locating lugs and the respective apertures.

20. A clinching apparatus according to claim 18 wherein the retaining means comprises a circlip surrounding the forming elements and protruding radially from a remote end of the die, such that the maximum axial excursion of the die in the second direction corresponds to a point at which the circlip abuts a corresponding surface of the guide block.

21. A clinching apparatus according to claim 20 wherein the guide block is retained within the body with an interference fit.

22. A clinching apparatus according to any one of the preceding claims, further including independently operable clamping means to clamp the sheet material intermediate the punch and the die.

23. A clinching apparatus according to claim 22 wherein said clamping means includes a press having a clamping member defining a generally annular clamping surface coaxial with the punch and cooperable with a corresponding opposed surface of the die such that selective actuation of the clamping press urges the clamping member toward the die, thereby clamping the sheet material between the clamping surface and the corresponding opposed surface of the die and simultaneously forcing the forming elements into the guide block to close the die prior to actuation of the punch to form the clinch.

24. A clinching apparatus according to claim 23 wherein

the clamping surface is generally convex in configuration.

25. A clinching apparatus according to claim 24 wherein the clamping surface incorporates an outwardly protruding generally annular shoulder surrounding the punch to urge the sheet material into the void.

26. A clinching apparatus according to any one of the preceding claims wherein the void defined by the die is non-circular in cross-sectional configuration, such that the clinch prevents relative rotation of the overlapping portions of sheet material.

27. A clinching apparatus according to claim 26 wherein the void incorporates at least one lobe or protrusion to form a clinch adapted to resist relative rotation of overlapping portions of sheet material.

28. A clinching apparatus according to claim 26 or claim 27 wherein the void is generally polygonal in cross sectional configuration.

29. A clinching apparatus according to any one of claims 26 to 28 wherein the die comprises at least four complementary collets.

30. A clinching apparatus according to claim 29 wherein the remote ends of the collets together form a cylindrical end portion of the die adapted for sliding engagement within a complementary cylindrical socket within the guide block and wherein the collets are held together by a circlip.

31. A multi-cylinder actuating device for a clinching apparatus according to any one of the preceding claims, said actuating device including a first force exerting member reciprocably moveable by a first fluid cylinder, and a second force exerting member reciprocably moveable independently of said first member by a second fluid cylinder, an outer surface of said first member forming an inner surface of said second cylinder such that an operating volume of said second cylinder is defined partly by said first member.

32. An actuating device according to claim 31 wherein said first and said second cylinders are hydraulically or pneumatically operable.

33. A clinching assembly comprising a clinching apparatus according to any one of claims 20 to 30 and an actuating device according to claim 31 or claim 32 wherein the first force exerting member actuates the punch and the second force exerting member independently actuates the clamping means.

34. A clinching assembly according to claim 33 wherein the actuating device and the clinching apparatus are maintained in relative coaxial alignment by a generally C-shaped support frame.

35. A clinching apparatus substantially as hereinbefore described with reference to any one of figures 1 to 11 of the accompanying drawings.

36. An actuating device substantially as hereinbefore

described with reference to figure 12 of the accompanying drawings.

37. A clinching assembly substantially as hereinbefore described with reference to figure 13 of the accompanying drawings.

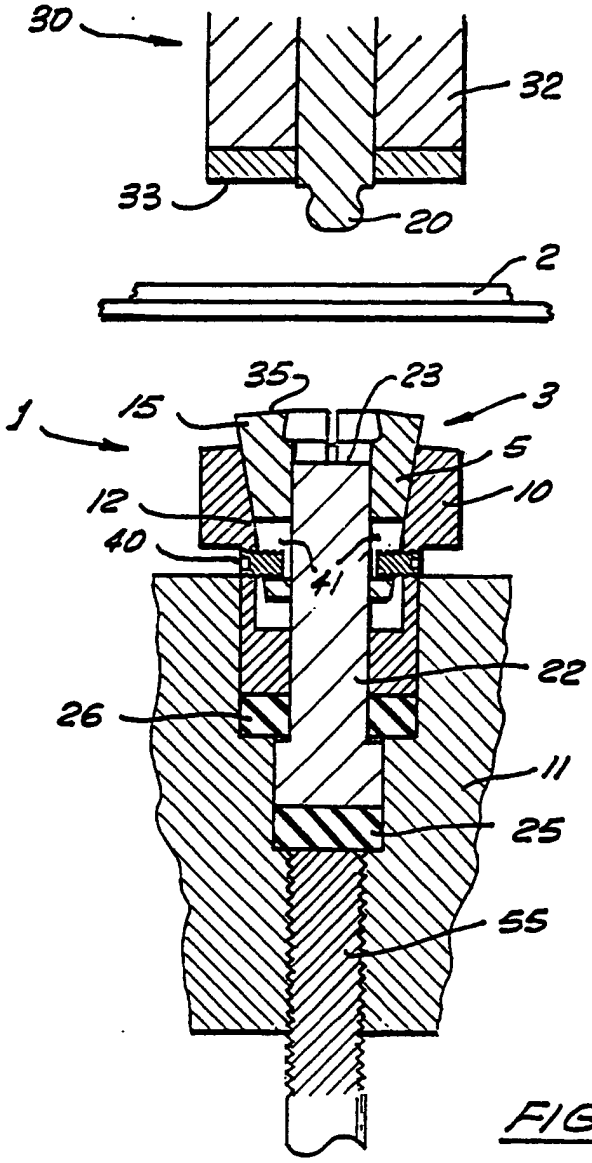

FIG.1

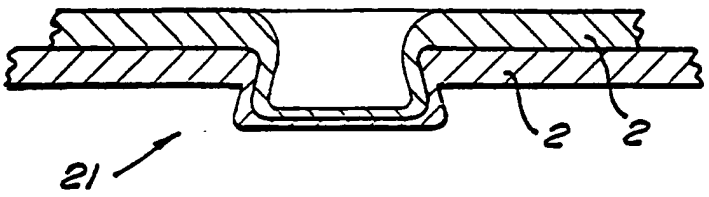

FIG. 3

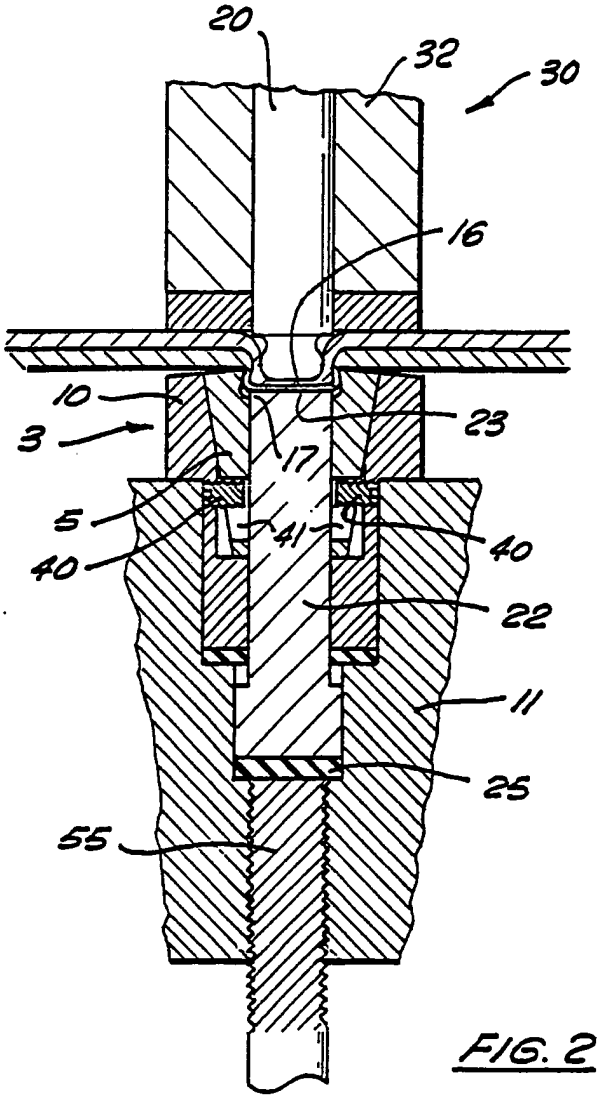

FIG. 2

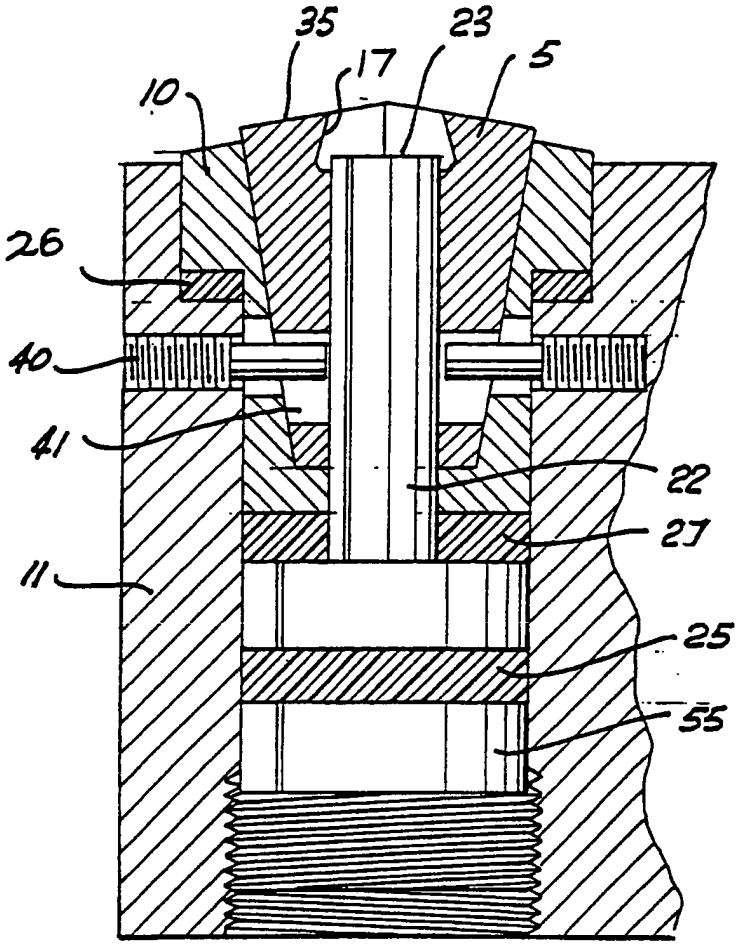

FIG. 4

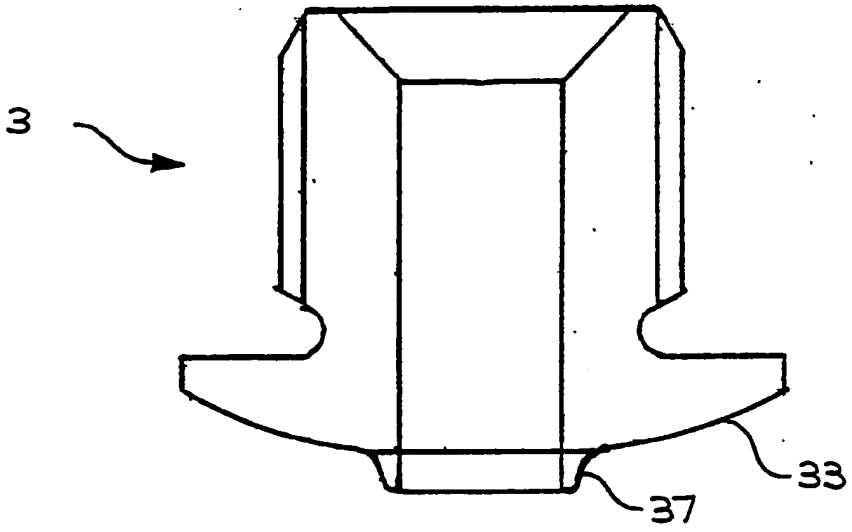

FIG 5

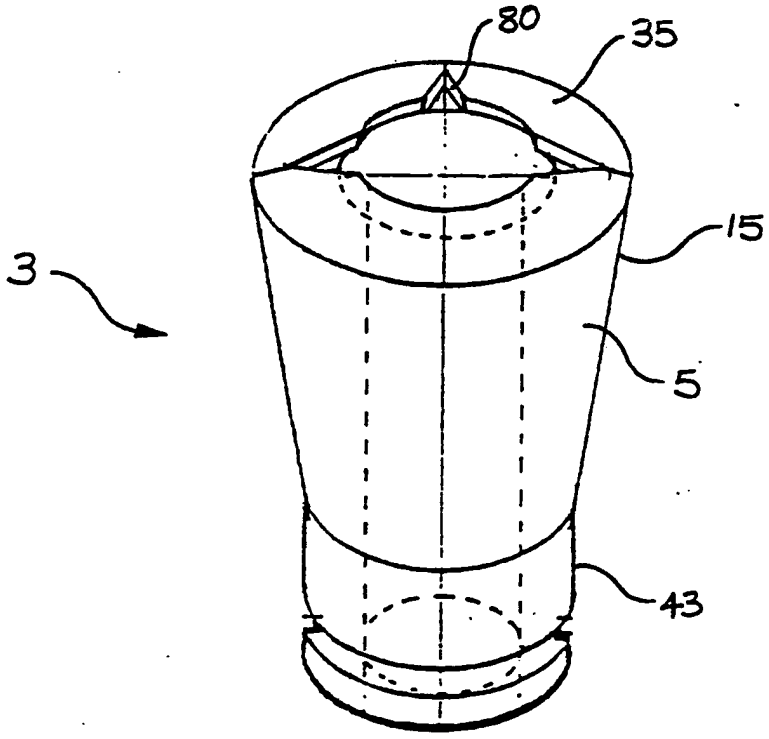

FIG 6

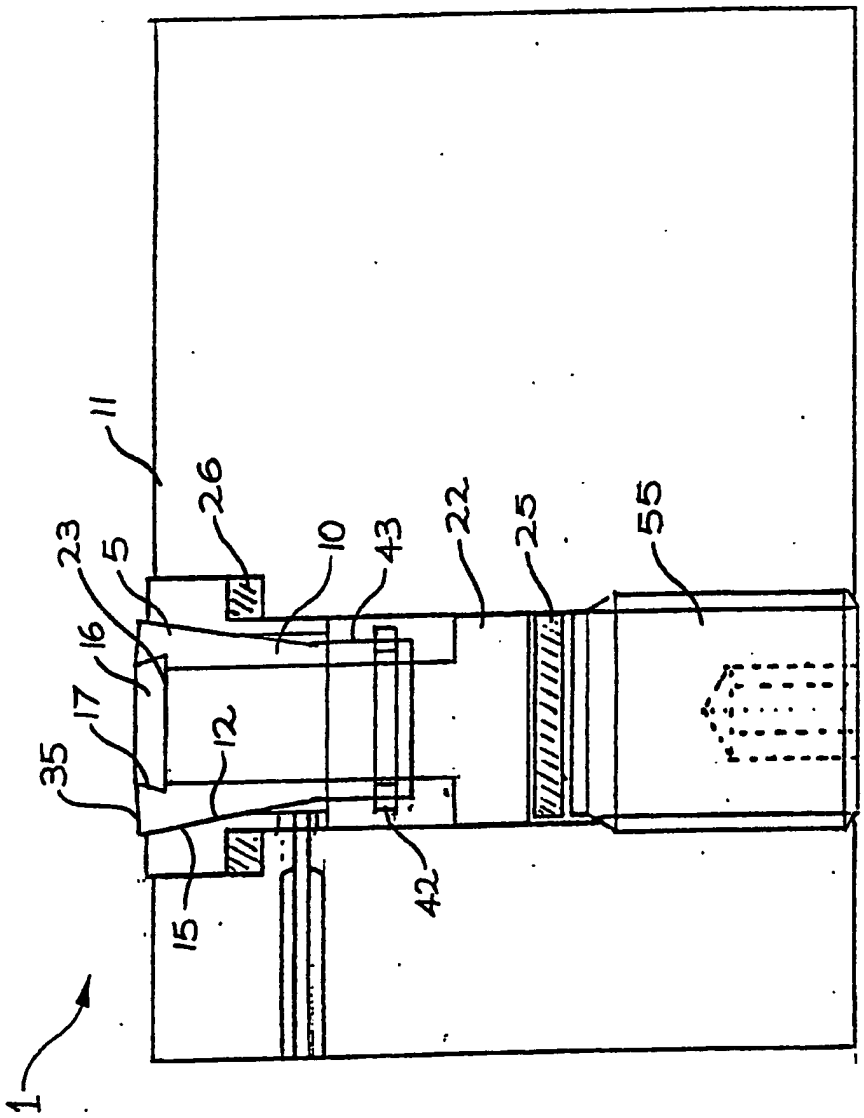

FIG 7

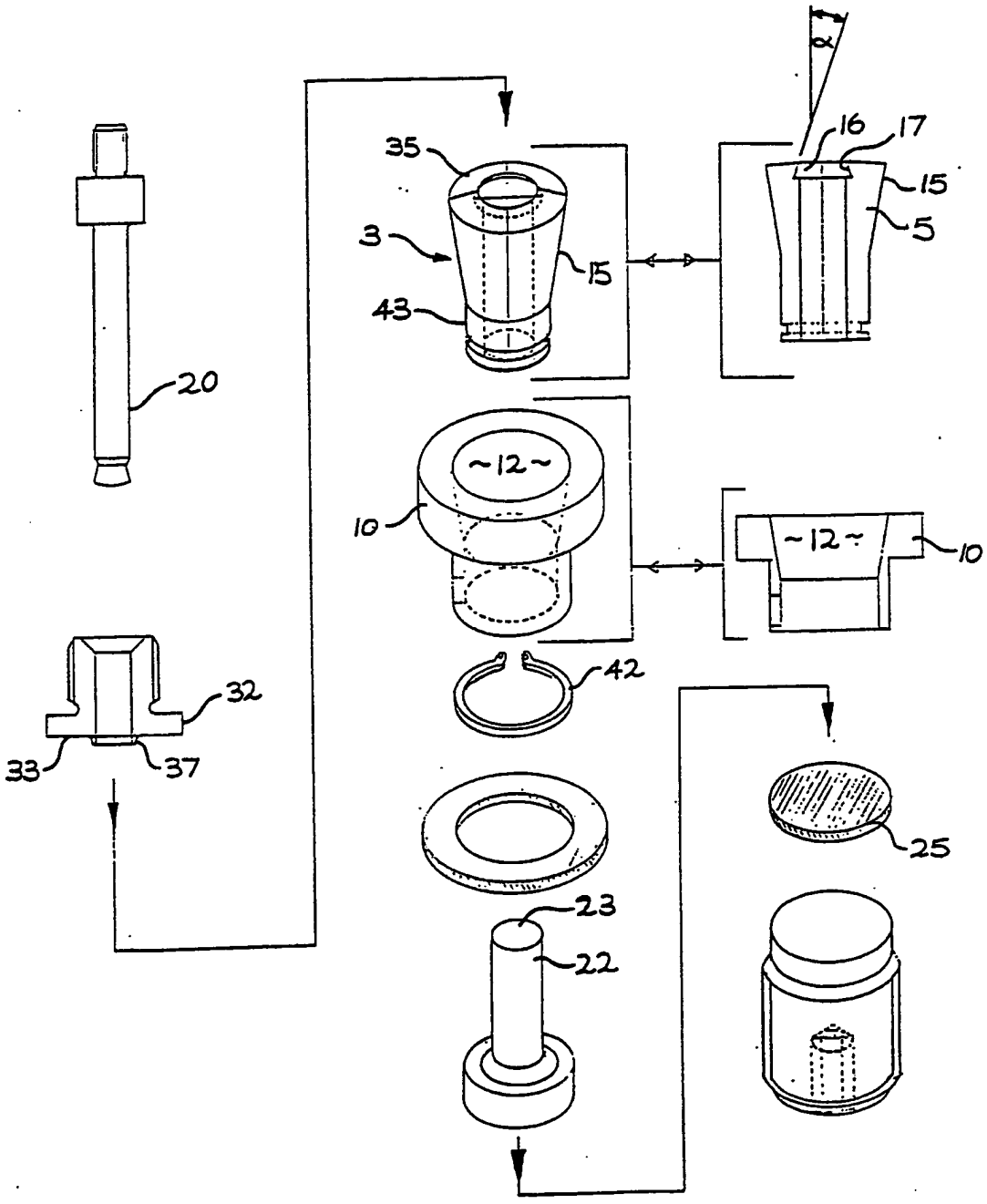

FIG 8

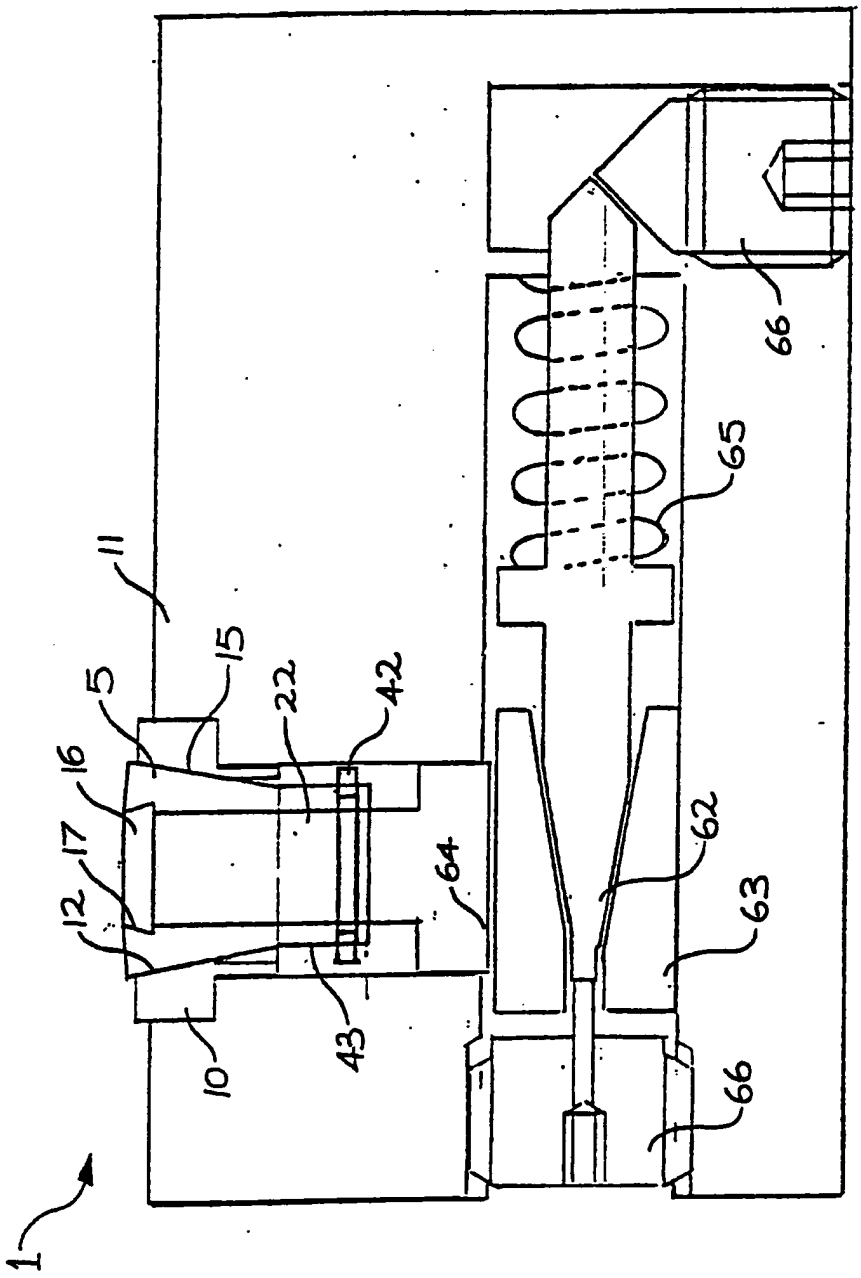

FIG 9

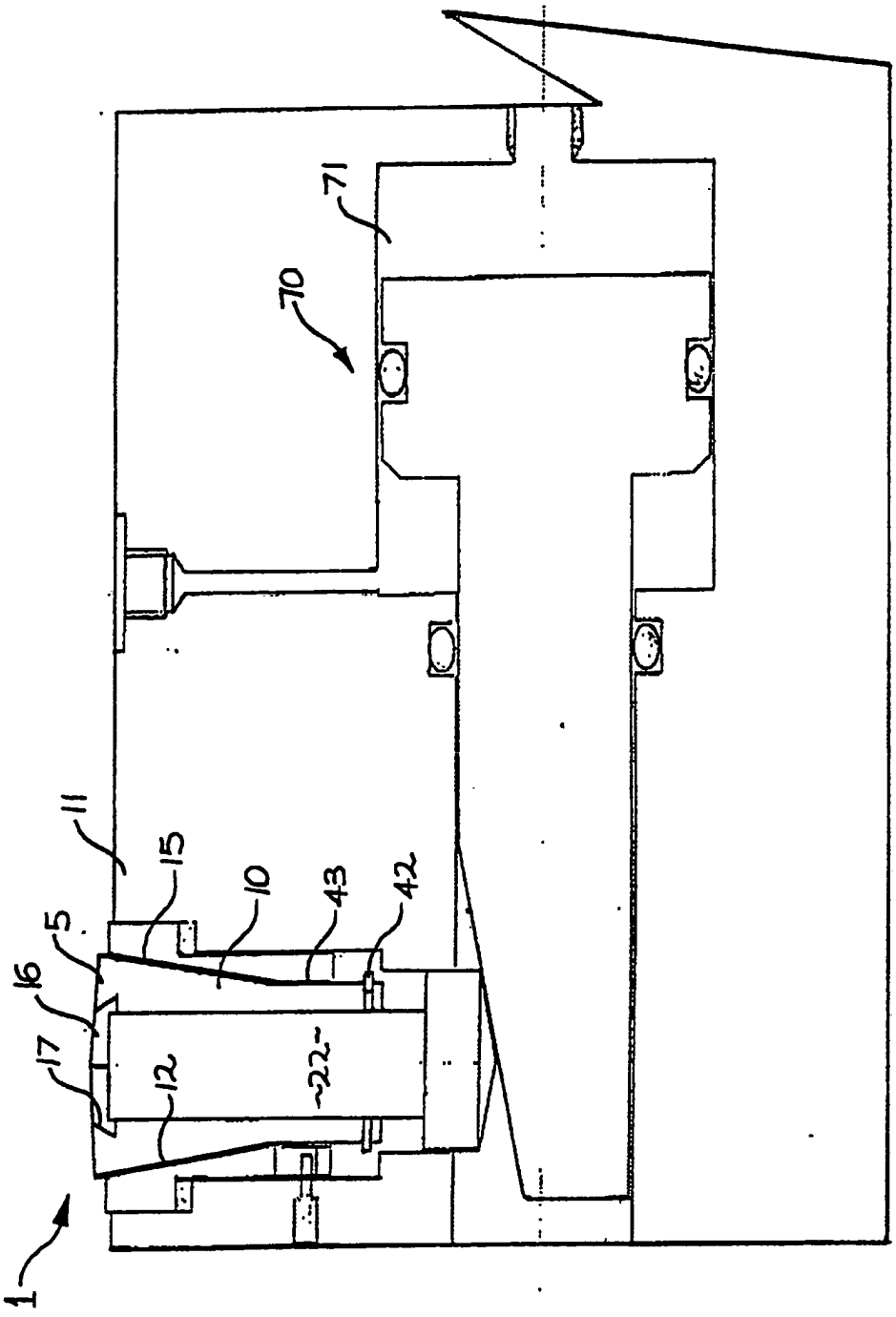

FIG 10

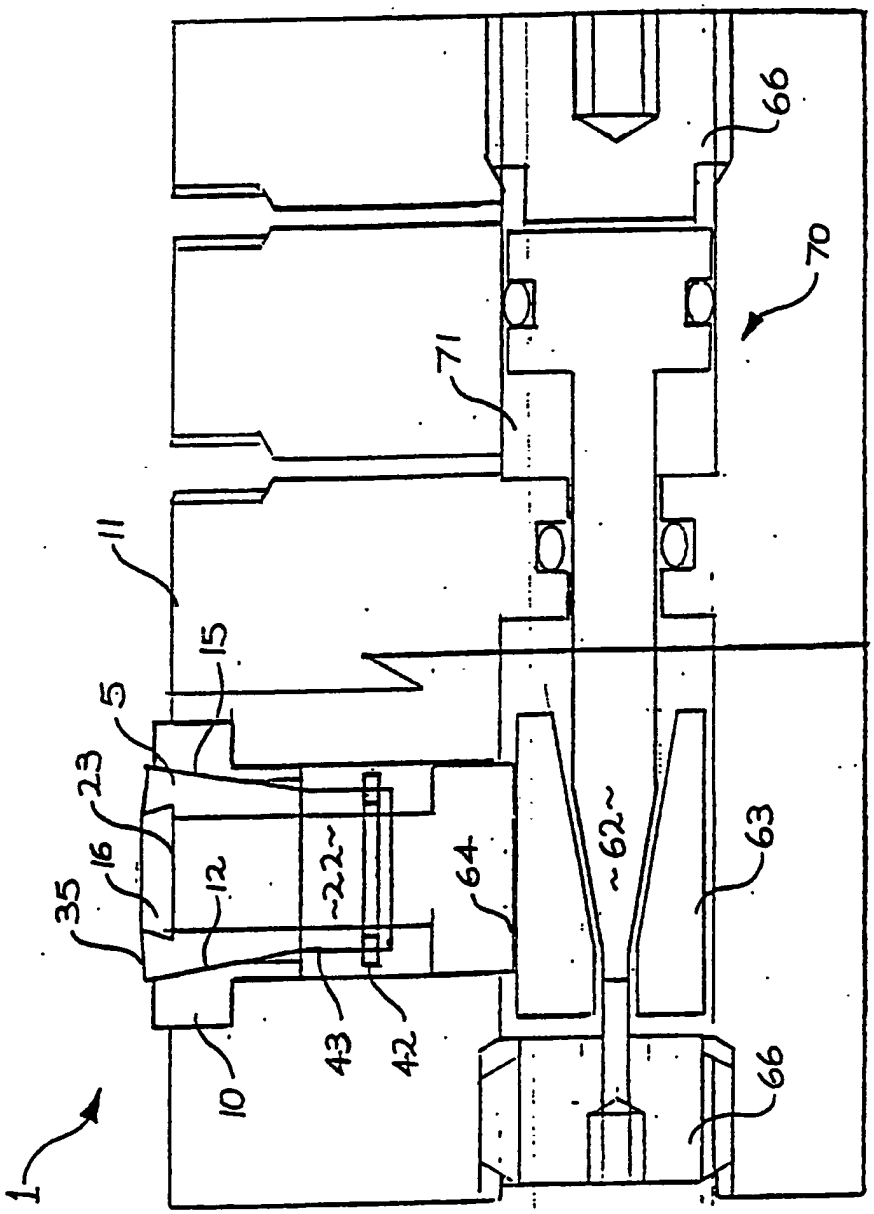

FIG 11

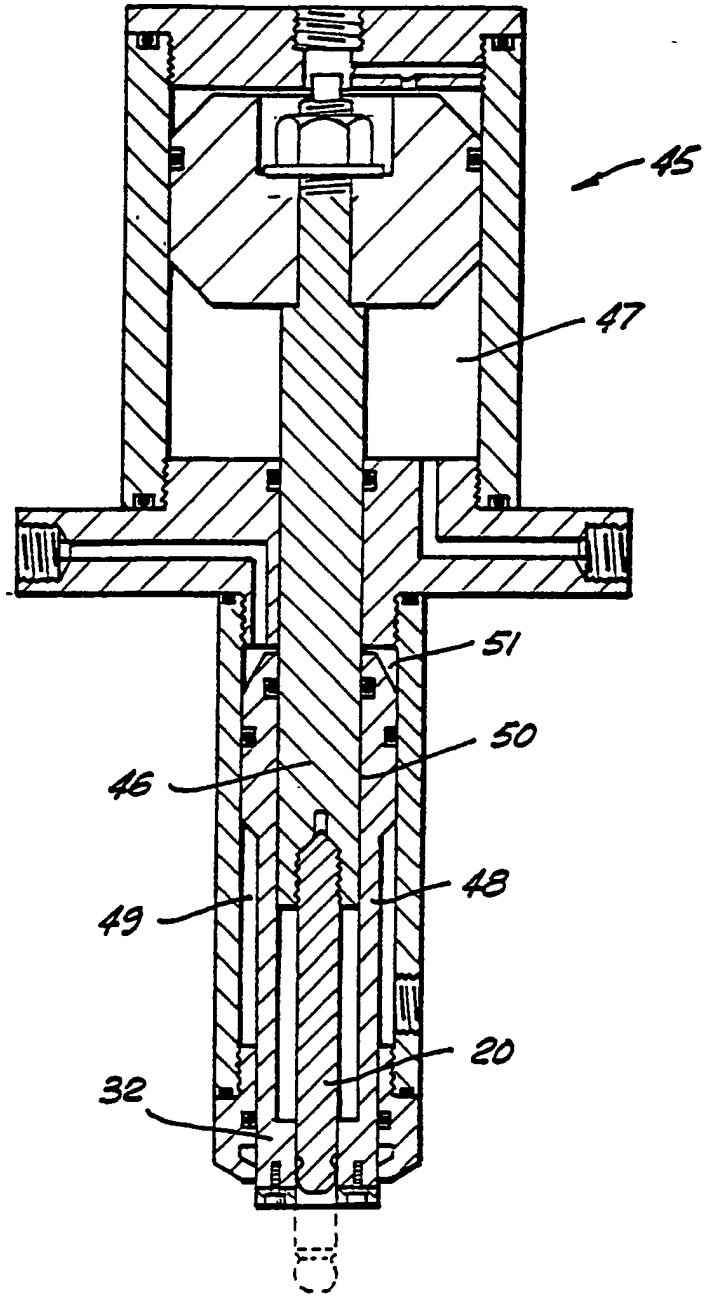

FIG. 12

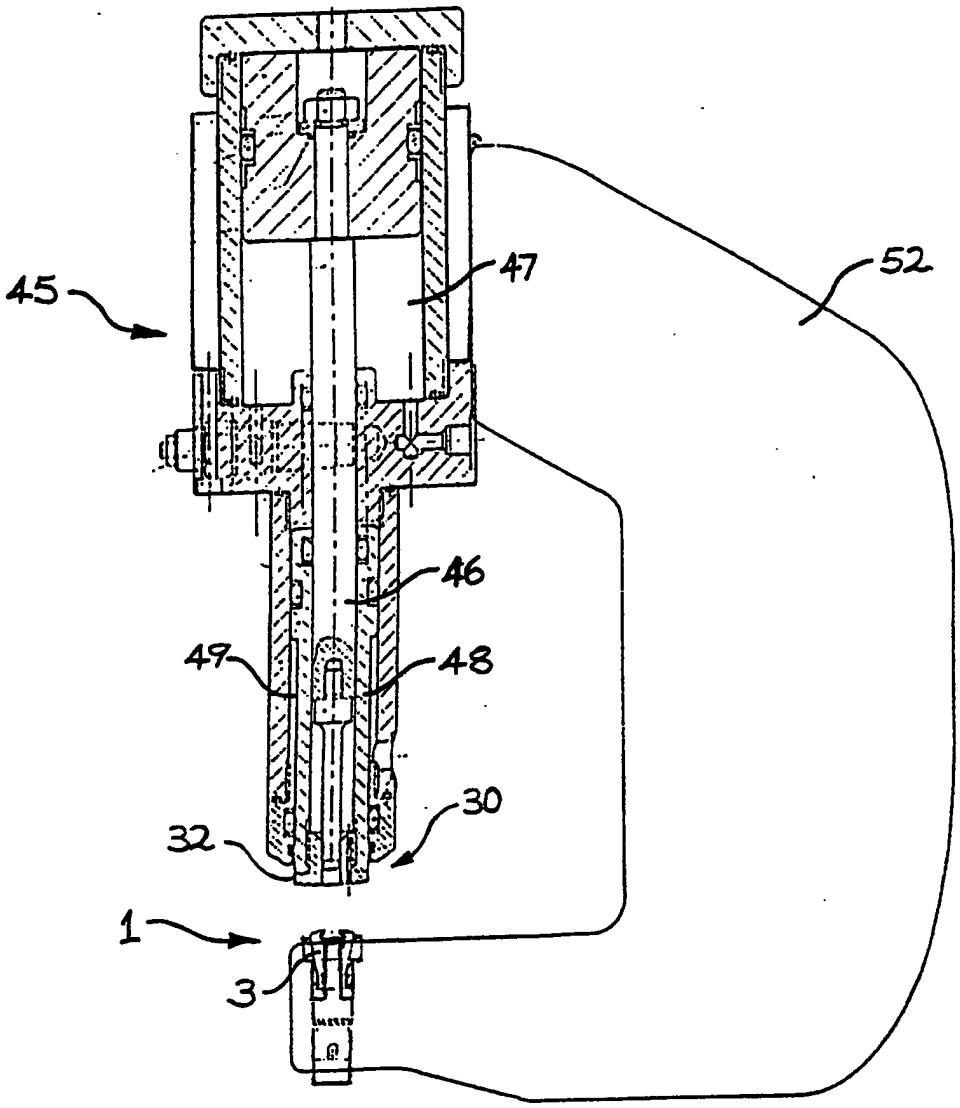

FIG 13

INTERNATIONAL SEARCH REPORT

International Application No. PCT/AU 91/00120

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) 6

According to International Patent Classification (IPC) or to both National Classification and IPC

Int. Cl.[5] B21D 039/00, 039/03

II. FIELDS SEARCHED

Minimum Documentation Searched 7

Classification System	Classification Symbols
IPC	B21D 039/00, 039/03

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched 8

AU : IPC as above

III. DOCUMENTS CONSIDERED TO BE RELEVANT 9

Category*	Citation of Document, [11] with indication, where appropriate, of the relevant passages 12	Relevant to Claim No 13
X,Y	Patents Abstracts of Japan, M-649, page 74, JP 62-148034 2 July 1987 (02.07.87) See whole document	(1-5)
A	Patents Abstracts of Japan, M 772, page 143, JP 63-192524 (SHARP CORP) 9 August 1988 (09.08.88)	(1)
A	GB,A, 2189175 (BTM CORPORATION) 21 October 1987 (21.10.87)	(1)
A	US,A, 4459735 (SAWDON) 17 July 1984 (17.07.84)	(1)
Y	US,A, 4569111 (MUTOV) 11 February 1986 (11.02.86)	(1)

* Special categories of cited documents: 10

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

IV. CERTIFICATION

Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report
24 May 1991 (24.05.91)	31 May 1991
International Searching Authority	**Signature of Authorized Officer**
Australian Patent Office	D.G. FRY

Form PCT/ISA/210 (second sheet) (January 1985)

FURTHER INFORMATION CONTINUED FROM THE SECOND SHEET

V. [ ] OBSERVATIONS WHERE CERTAIN CLAIMS WERE FOUND UNSEARCHABLE 1

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1.[ ] Claim numbers ..., because they relate to subject matter not required to be searched by this Authority, namely:

2.[ ] Claim numbers , because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3.[ ] Claim numbers ..., because they are dependent claims and are not drafted in accordance with the second and third sentences of PCT Rule 6.4 (a):

VI. [ ] OBSERVATIONS WHERE UNITY OF INVENTION IS LACKING 2

This International Searching Authority found multiple inventions in this international application as follows:

The independent claim 36, defining an actuating device with reference to fig 12 of the drawings does not link with the rest of the claims relating to a clinching apparatus/assembly to form a single inventive concept.

1.[ ] As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims of the international application.

2.[ ] As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims of the international application for which fees were paid, specifically claims:

3.[ ] No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claim numbers:

4. [X] As all searchable claims could be searched without effort justifying an additional fee, the International Searching Authority did not invite payment of any additional fee.

Remark on Protest

[ ] The additional search fees were accompanied by applicant's protest.

[ ] No protest accompanied the payment of additional search fees.

ANNEX TO THE INTERNATIONAL SEARCH REPORT ON INTERNATIONAL APPLICATION NO. PCT/AU 91/00120

This Annex lists the known "A" publication level patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent Document Cited in Search Report	Patent Family Members		
GB 2189175	US 4910853	CA 1166832	CA 1184019
	DE 3106313	JP 57050224	JP 60087935
	MX 155014	US 4459735	
US 4459735	CA 1166832	CA 1184019	DE 3106313
	GB 2087284	GB 2123734	JP 60087935
	MX 155014	US 4459735	US 4757609
	US 4910853		
US 4569111	GB 2069394	JP 56114536	MY 546/85

END OF ANNEX